

spm 9550: Introduction to Agent Based Modeling Dr. ir. Igor Nikolic 12-03-10



Challenge the future

Lecture goals

- Understand what is an Agent, and what is an Agent Based Model
- Understand the concepts of generative science
- Understand how bottom up modeling is different from other modeling techniques



Three main schools of Agent thinking

- Artificial Intelligence AI
 - Agents as autonomous identities solving problems
- Multi-Agent Systems MAS
 - Distributed control of systems
- Agent Based Modeling (and Simulation) ABM(S)
 - Simulating (real world) phenomena
- We will follow the ABM(S) view !



Agent Based Model

• An Agent is a persistent thing which has some state we find worth representing, and which interacts with other agents, mutually modifying each other's states.

The components of an agent-based model are a collection of agents and their states, the rules governing the interactions of the agents and the environment within which they live.

C.R. Shalizi. Methods and techniques of complex systems science: An overview. *arXiv.org*, arXiv.org:nlin/0307015, 2006. URL http://www.citebase.org/abstract?id=oai:arXiv.org:nlin/0307015.



Agent

• Agent is a thing that does things to other things





Environment

- What the Agent is in.
- Everything that is *not* an Agent, but is relevant.
- It affects the Agent, and Agent can affect it.



States

- Things Agents know or have (including memory)
- Can be private or public
- Can be static or dynamic and can depend on the Rules
- Eg:
 - Profits
 - Color
 - Location
 - Sex
 - Age
 - Contracts
 - etc...





Rules

- What and how they do with what they know
 - I see a tiger ! Should I :
 - Run away faster than others
 - Scream really loud
 - Die a messy death
 - I need Polycarbonate (PC) so that I can produce bottles
 - Who can sell me PC ?
 - Who is the cheapest supplier ?
 - How do I make a bottle from PC ?
- Rules can be static or dynamic and depend on the States



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Actions

- Based on
 - Other Agents
 - States
 - Rules
- Agent will perform (or not perform) some action
- Action can
 - Affect other Agents
 - Own state
 - Own rule
 - Environment



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Exercise

• Identify the

- Environment
- Agents
- States
- Rules
- Actions

"Piled Higher and Deeper" by Jorge Cham www.phdcomics.com

http://www.phdcomics.com/comics/archive.php?comicid=1077



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Top-Down modeling

- Start with the entire system
 - Assumes that you know how the system behaves
 - Formalize (encode) your understanding
 - Try to replicate the observed regularity
- System description is static



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Works fine as long as

- You have good understanding of the system is in its entirety
- You understand exactly how system components interact with each other.
- Works great for airplanes, chemical factories, busses and glue.
- However, for complex stuff, like socio-technical systems, we need something else...



Generative Science

- "If you did not grow it, you did not explain it!" (Epstein 1999)
 - build understanding from the bottom up !
- Central principle :
 - phenomena can be described in terms of interconnected networks of (relatively) simple units. Deterministic and finite rules and parameters of natural phenomena interact with each other to generate complex behavior

J.M. Epstein. Agent-based computational models and generative social science. *Complexity*, 4 (5):41–60, 1999.



Generativist Question

• How could the decentralized local interactions of heterogeneous autonomous agents generate the given regularity?





Generativist Experiment

 Situate an initial population of autonomous heterogeneous agents in a relevant spatial environment; allow them to interact according to simple local rules, and thereby generate - or 'grow' the macroscopic regularity from the bottom up.



Observed regularity







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Firm as an Agent



Many different agents





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That matches an observed regularity



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